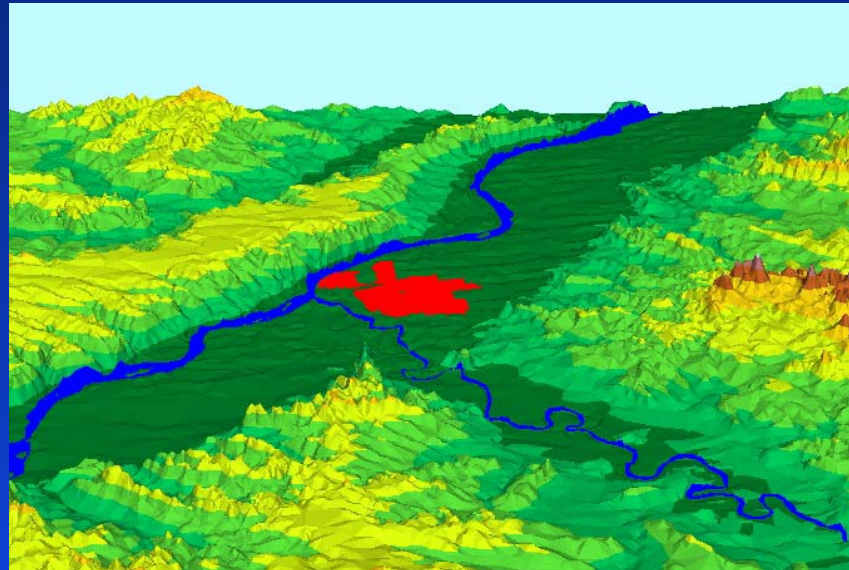




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Omaha District

OTHA – Omaha Tools for Hydrologic Analysis



William Doan, P.E.

Hydraulic Engineer, U.S. Army Corps of Engineers,
Omaha District



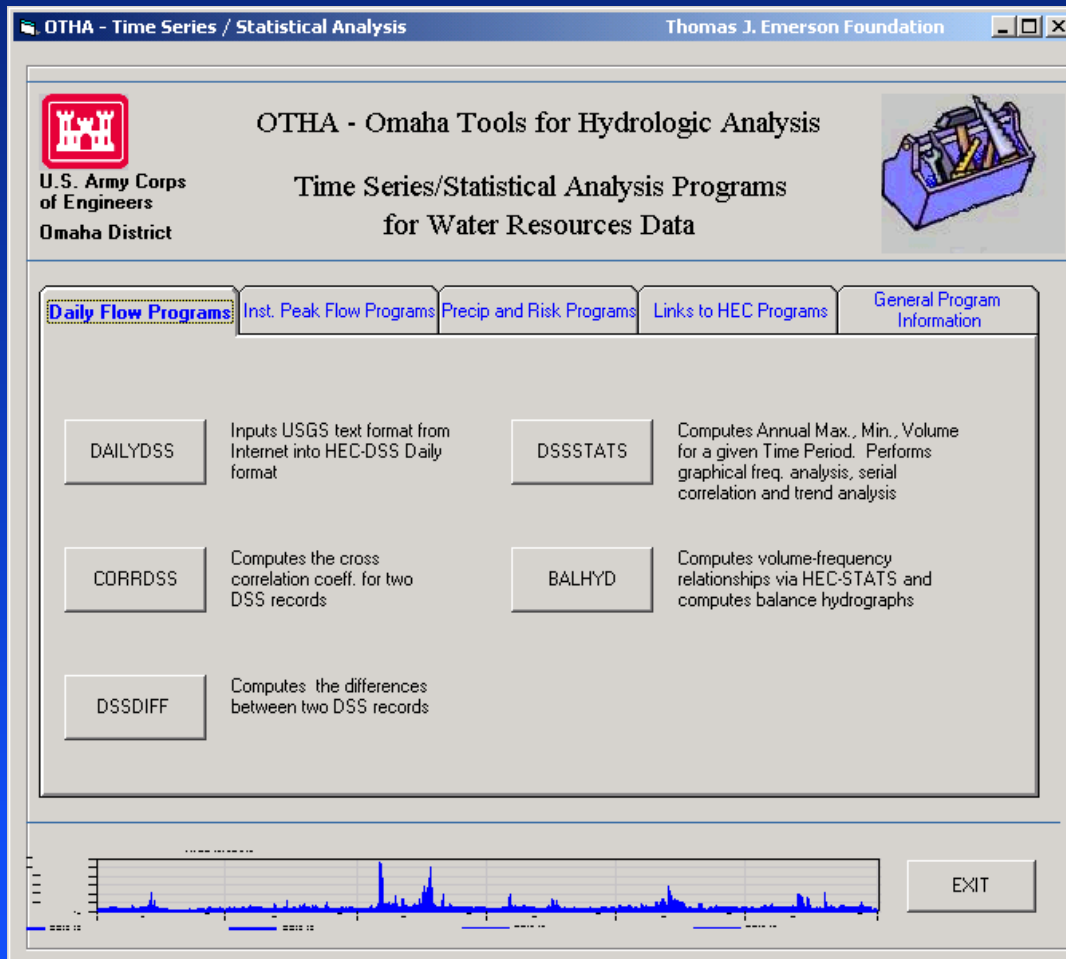
bill.p.doan@usace.army.mil



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OTHA – Omaha Tools for Hydrologic Analysis

Time-Series/Statistical Analysis Programs for Water Resources



-What is it?

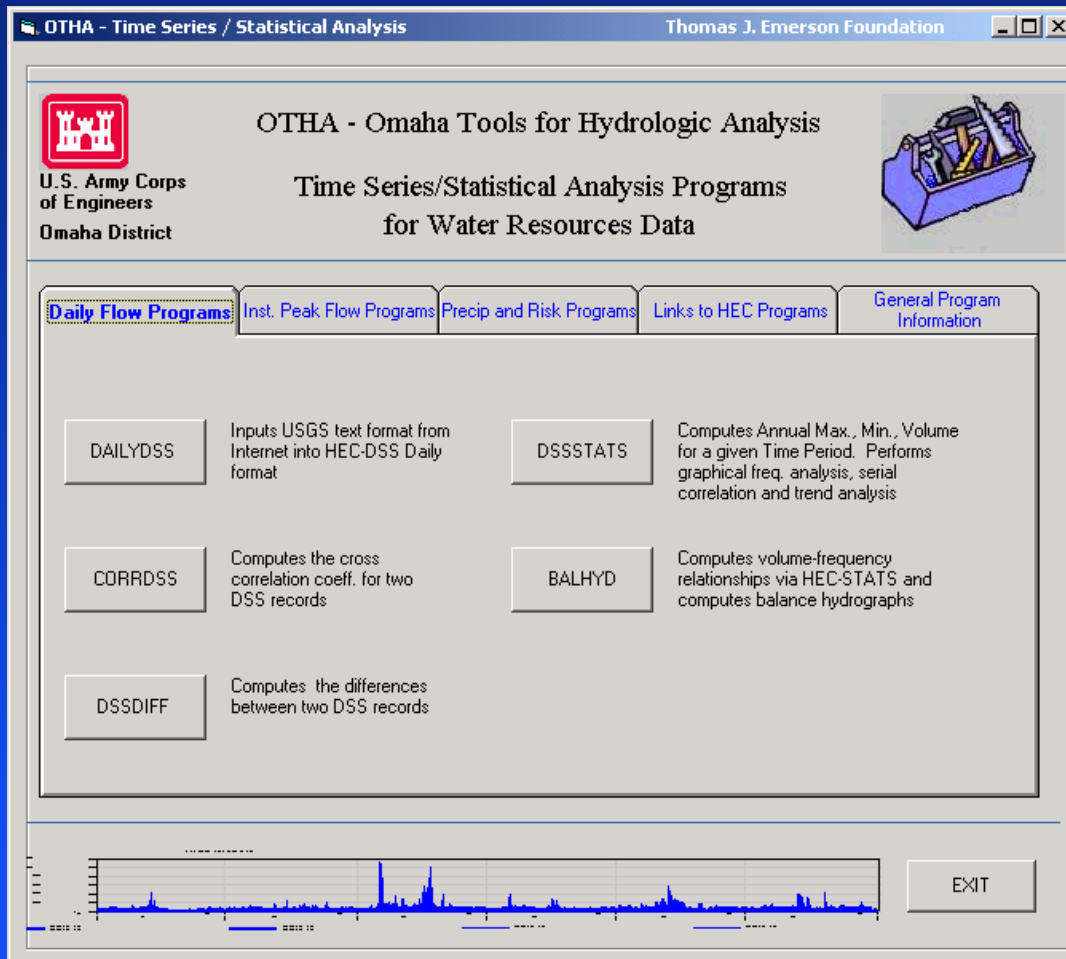
- Collection of programs/routines written in Omaha District on an “as-needed” basis
- “Advanced” statistical routines to use in conjunction with HEC-FFA, STATS
- Small, simple, stand-alone routines
- FORTRAN engines/VB GUI Interfaces
- Toolbox for time-series and statistical analyses.





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OTHA – Omaha Tools for Hydrologic Analysis



- SPECIFIC MODELLING GOALS:

- Direct access to data via the Internet
- Convert data to standardized format
(DSS - Daily Flow and FFA Input - Peak Flow)
- Provide for monthly, seasonal, or annual analysis
- Provide a common “look or feel” for all routines
- Provide a useful tool for working engineers
- Quick “tour” of program






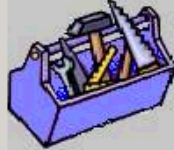
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 **OTHA - Omaha Tools for Hydrologic Analysis**

**Time Series/Statistical Analysis Programs
for Water Resources Data**



Daily Flow Programs Inst. Peak Flow Programs Precip and Risk Programs Links to HEC Programs General Program Information

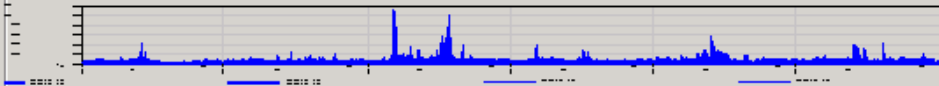
DAILYDSS Inputs USGS text format from Internet into HEC-DSS Daily format

DSSSTATS Computes Annual Max., Min., Volume for a given Time Period. Performs graphical freq. analysis, serial correlation and trend analysis

CORRDSS Computes the cross correlation coeff. for two DSS records

BALHYD Computes volume-frequency relationships via HEC-STATS and computes balance hydrographs

DSSDIFF Computes the differences between two DSS records



EXIT







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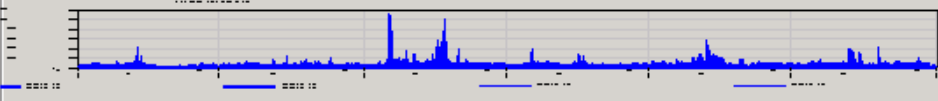
 **OTHA - Omaha Tools for Hydrologic Analysis**


**Time Series/Statistical Analysis Programs
for Water Resources Data**



[Daily Flow Programs](#) [Inst. Peak Flow Programs](#) [Precip and Risk Programs](#) [Links to HEC Programs](#) [General Program Information](#)

QWAT	Converts USGS WATSTORE file- format from Internet into an HEC-FFA Input File	QGEN	Given two gages - will generate missing years' peak flows for the 2nd based on the 1st using linear regression, Ir w/noise, and MOVE statistics
EXTENSION	Extension of records or Two-Station Comparison of Peak Flows - via Bulletin 17B Appendix 7	STATIONARITY	Performs trend analysis on statistical parameters: mean log Q, SD, skew and tests for statistical significance using t-distribution
TOTPROB	Computes total probability of flooding from two independent populations utilizing the Total Probability Theorem using statistical parameters	MIXPOPS	For different populations within one FFA record, will compute separate curves, then combine curves using the Total Probability Theorem

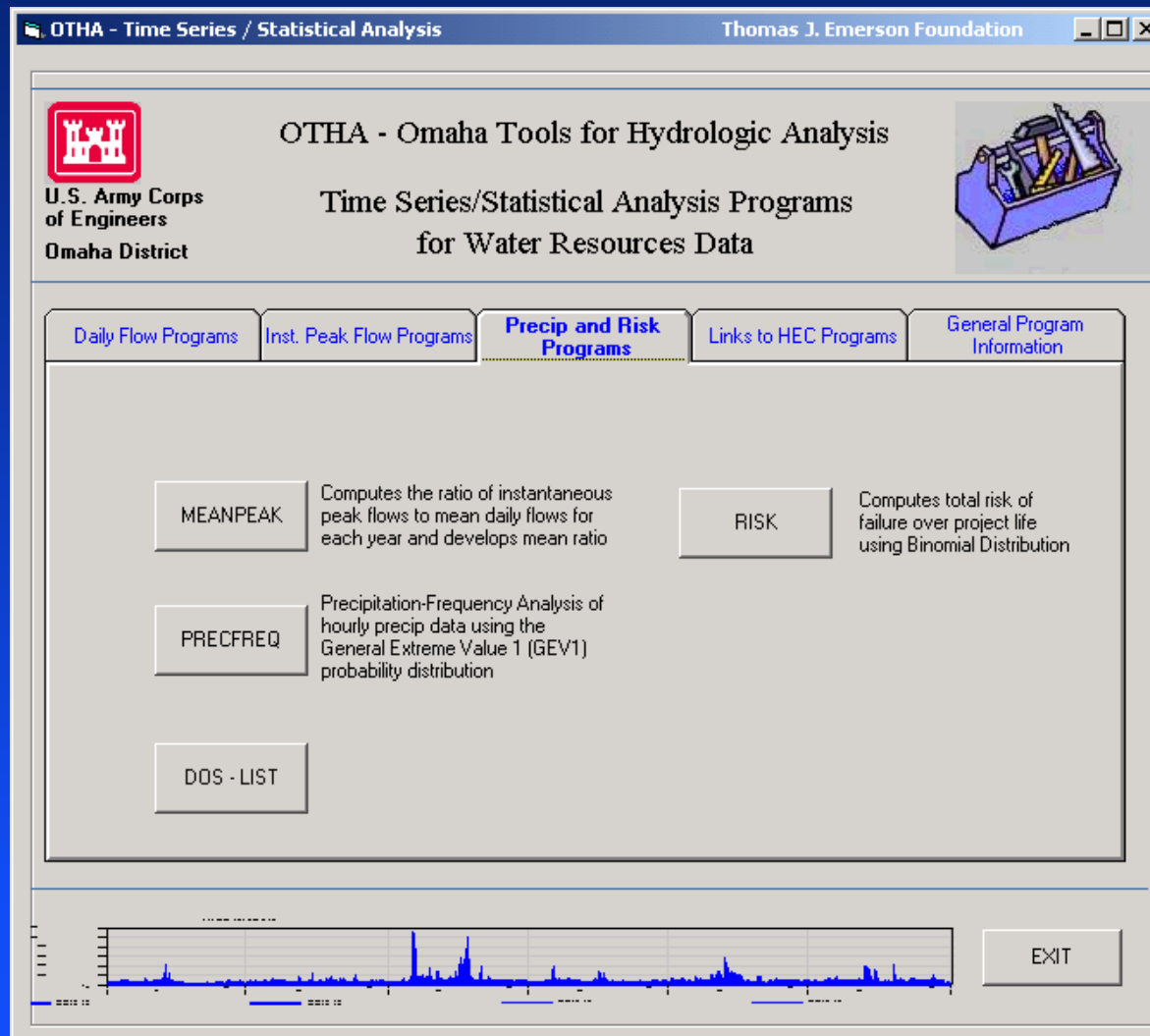
 [EXIT](#)





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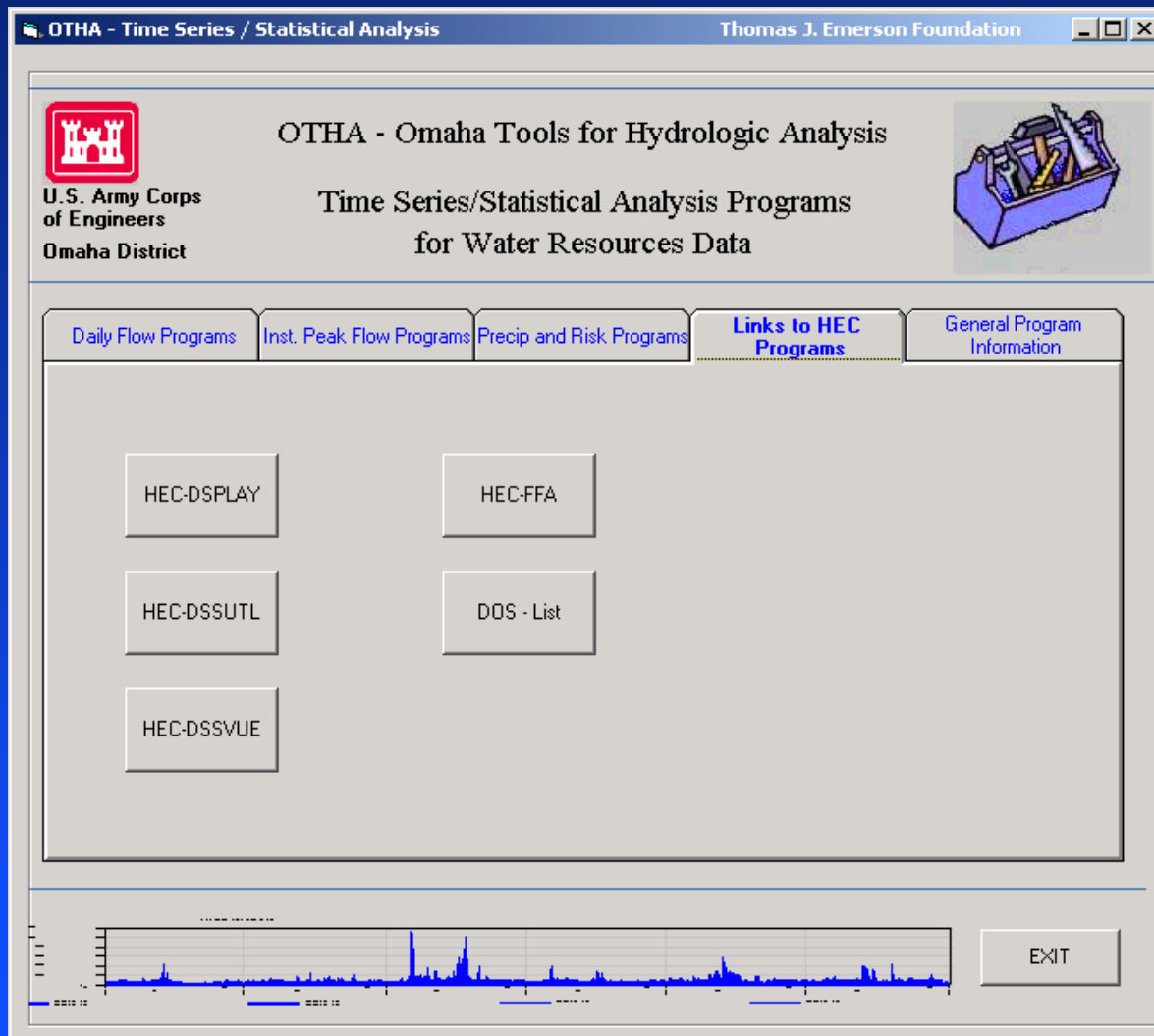
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OTHA - Time Series / Statistical Analysis

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Time Series/Statistical Analysis Programs
for Water Resources Data

Daily Flow Programs

Inst. Peak Flow Programs

Precip and Risk Programs

Links to HEC Programs

General Program
Information


The software contained in OTHA was developed in the process of working on various water resources projects/analyses/ within the Hydrology Section, Omaha District, U.S. Army Corps of Engineers. All routines and interfaces were written by Bill Doan, except for:

PRECIFREQ - which was co-written by Warren Newbold

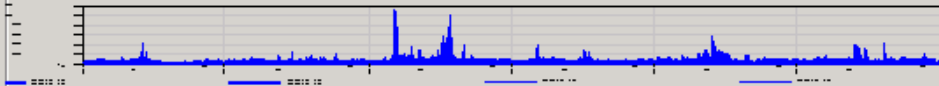
EXTENSION - which was written by Tom Navrkal

For further information concerning OTHA, please check-out the OTHA Web-Site at: <http://www.nwo.usace.army.mil/otha>

Because the software and related material are free and provided "as is," the authors, the USACE, and the United States Government have made no warranty, expressed or implied, as to accuracy or completeness and are not obligated to provide the user with any support, consulting, training or assistance of any kind with regard to the use, operation, and performance of this software nor to provide the user with any updates, revisions, new versions or "bug fixes." The user assumes all risk for any damages whatsoever resulting from loss of use, data, or profits arising in connection with the access, use, quality, or performance of this software, blah, blah, blah.



User's Manual.pdf



EXIT

Routines...

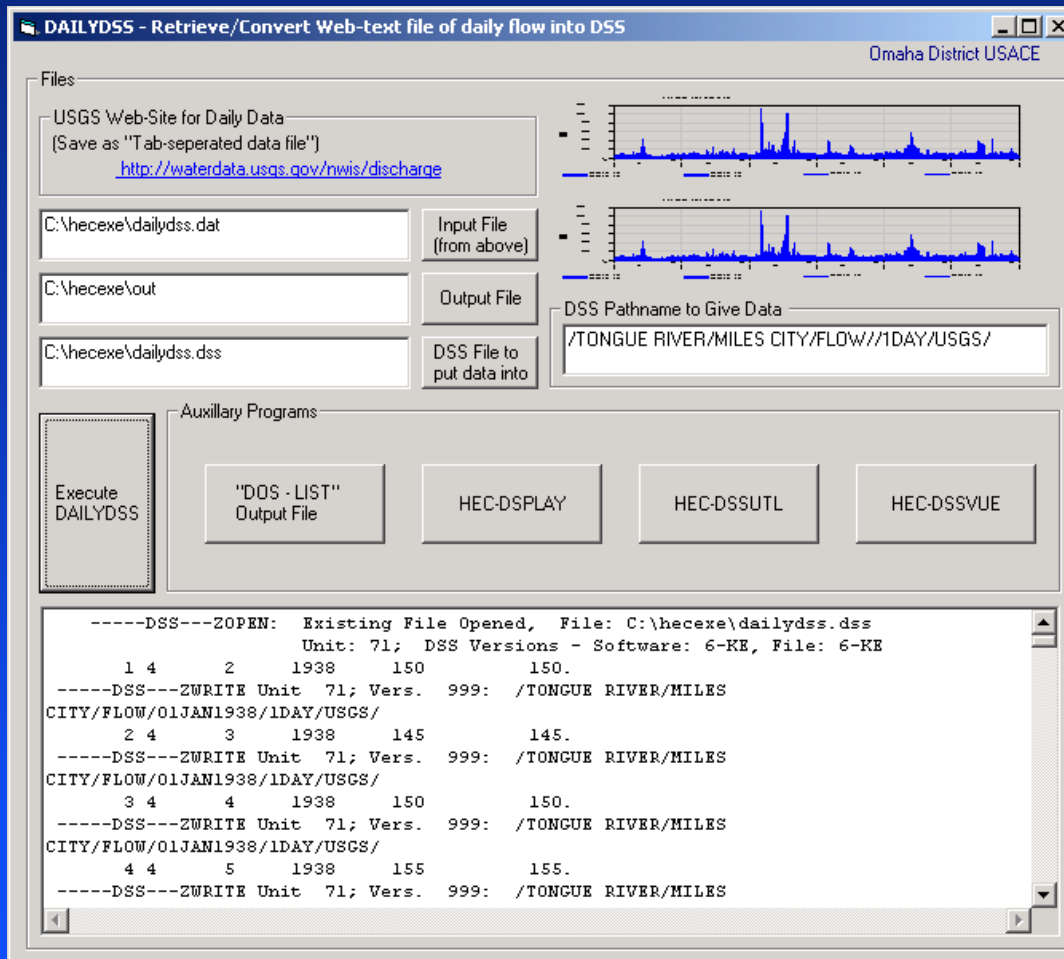




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DAILYDSS



- Retrieves/Converts USGS *Daily* flow data
- Links to USGS Daily Flow Site – using default browser
- Once find gage – download data (Save as “Tab-separated data file”)
- Give DSS filename and DSS Pathname
- Converts to DSS
- Also works on USGS “RECENT” data.





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DSSSTATS

DSSSTATS - Computes Max, Min, Mean Daily Values From DSS and and Puts Maxs into an FFA Input File Omaha District USACE

Files

C:\hecexe\dssstats.dss **DSS File**

DSS Pathname
/PLATTE R./NORTH BEND/FLOW//1DAY/USGS/

Dates and Periods

Starting Date: 01JAN1960 Ending Date: 31DEC2000

Starting Period: 01JAN Ending Period: 31DEC

C:\hecexe\out **Output File** C:\hecexe\infile.ffa **FFA Input File to Create**

Auxiliary Programs

Execute DSSSTATS "DOS - LIST" Output File HEC-DSPY HEC-DSSUTL HEC-DSSVUE

Statistical Analysis:

num of values	min value	date of min value	max value	date of max value	accum value*	mean value	lag-1 serial corr.
366	663.00	22DEC1960	67600.00	29MAR1960	3135.66	4326.96	0.8564
365	530.00	24JUL1961	12400.00	24MAY1961	2389.95	3306.98	0.9137
365	500.00	11DEC1962	32300.00	26MAR1962	3645.69	5044.55	0.9185

Graphical representation of flow data (hydrograph) showing peaks and troughs over time.

- Annual statistical summary of daily flows
- Min, max, means, volumes
- Monthly, seasonal, or annual basis
- Graphical Freq. Analysis
- Analytical Freq. Analysis
- Writes max flows out to FFA Input File
- Trend Analysis/Statistical Tests

- Example:





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OTHA – Omaha Tools for Hydrologic Analysis DSSSTATS - Example

Annual Period:

Statistical Analysis:

num of values	min value	date of min value	max value	date of max value	accum value*	mean value	lag-1 serial corr.
366	663.00	22DEC1960	67600.00	29MAR1960	3135.66	4326.96	0.8564
365	530.00	24JUL1961	12400.00	24MAY1961	2389.95	3306.98	0.9137
365	500.00	11DEC1962	32300.00	26MAR1962	3645.69	5044.55	0.9185
365	315.00	26JUL1963	14700.00	24JUN1963	2249.23	3112.27	0.9152
366	520.00	30JUL1964	21200.00	17JUN1964	2431.29	3354.98	0.7797
365	633.00	17AUG1965	26600.00	26MAY1965	3809.28	5270.90	0.8465

Monthly Period:

Statistical Analysis:

num of values	min value	date of min value	max value	date of max value	accum value*	mean value	lag-1 serial corr.
31	3230.00	30MAY1960	20300.00	07MAY1960	410.89	6694.19	0.8533
31	2850.00	03MAY1961	12400.00	24MAY1961	307.73	5013.55	0.9918
31	1700.00	15MAY1962	13400.00	20MAY1962	274.69	4475.16	0.8511
31	1880.00	28MAY1963	3860.00	02MAY1963	173.76	2830.97	0.7609
31	1460.00	25MAY1964	12700.00	27MAY1964	270.29	4403.55	0.5513
31	2760.00	17MAY1965	26600.00	26MAY1965	433.22	7058.06	0.9303





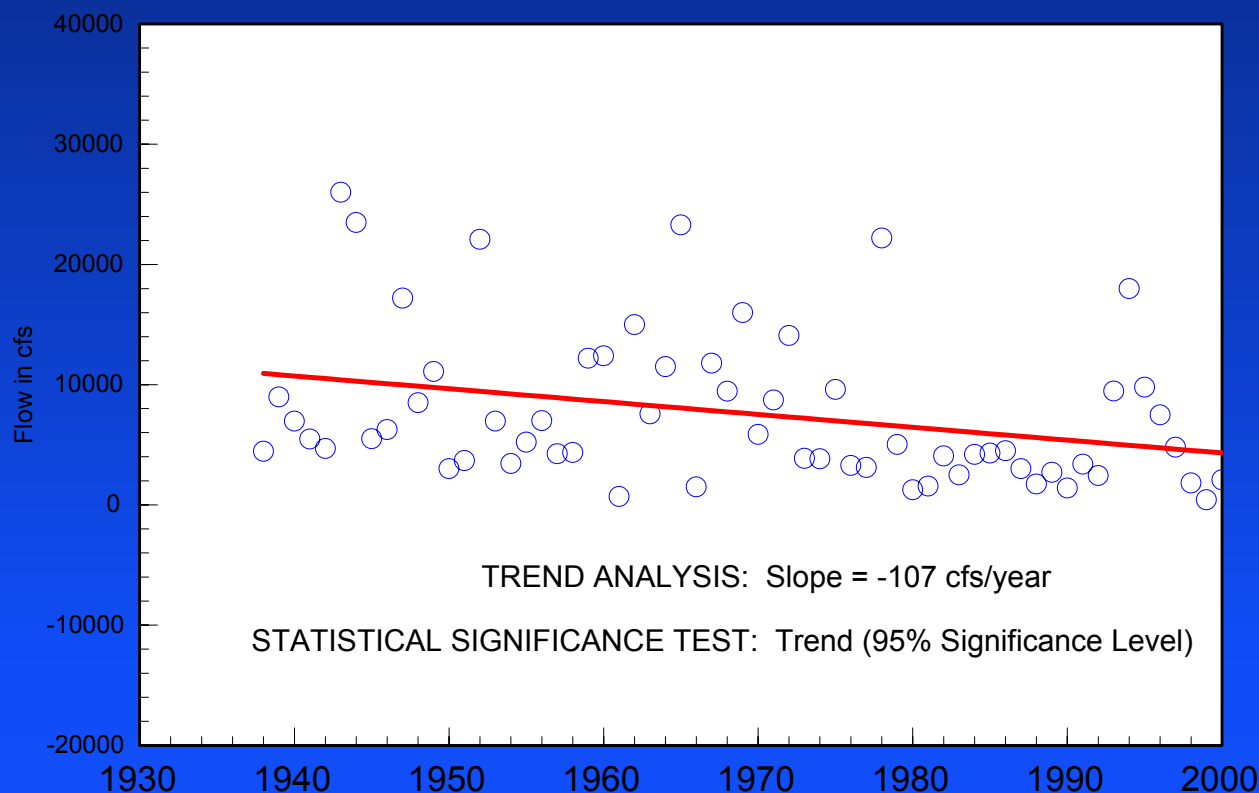
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DSSSTATS – Example (cont'd)

Trend Analysis:

Powder R. near Locate, MT
Annual Maximum Mean Daily Flows

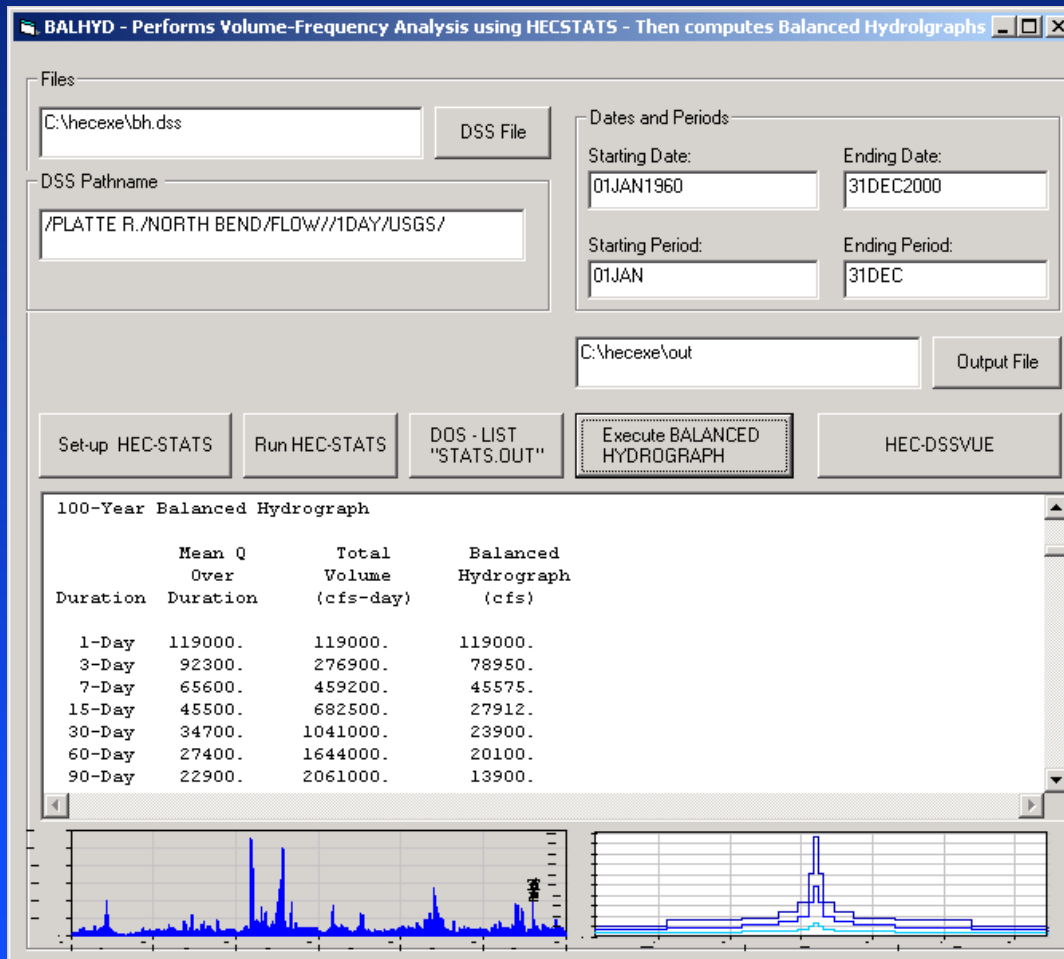




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BALHYD



- Serves as GUI for HEC-STATS
- Runs STATS (Vol-Freq) in “background”
- Takes STATS results and develops “Symmetrical Balanced Hydrographs”
- Writes 10-, 25-, 50-, 100-, and 500-year BH to HEC-DSS
- F-Part Path – “100-Year BH”
- Monthly, seasonal, or annual basis
- Example:

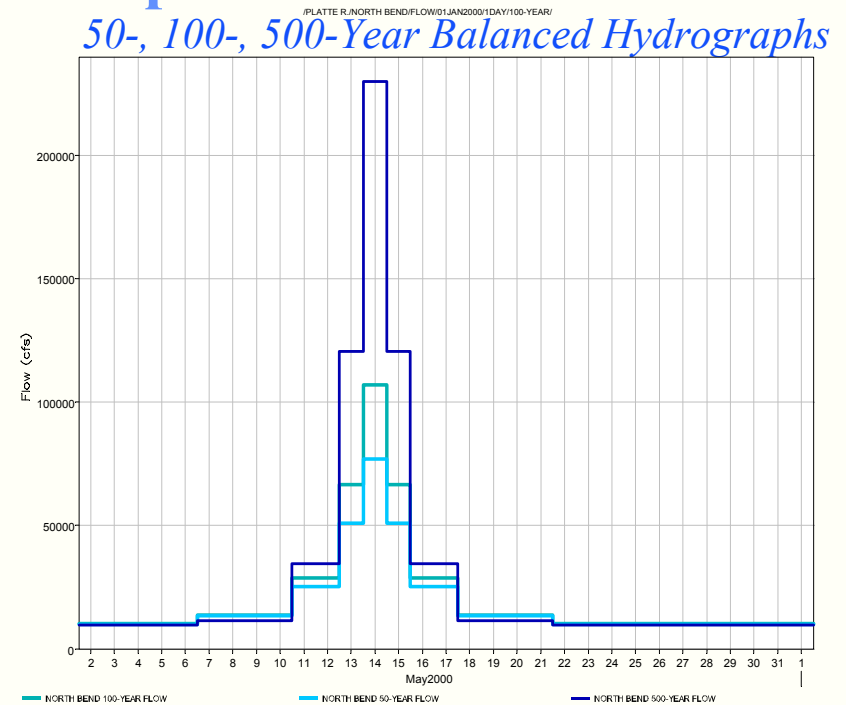
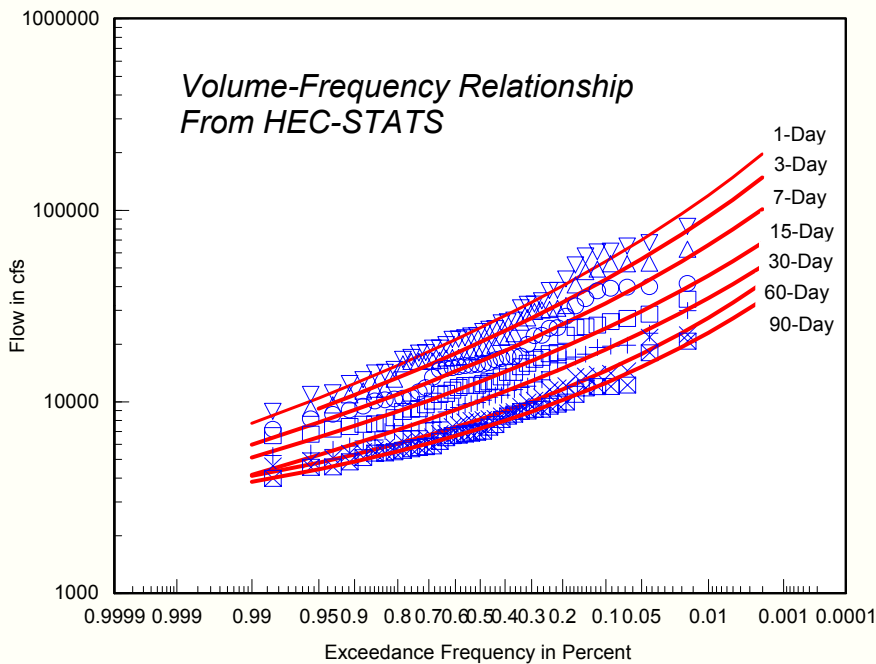




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BALHYD - Example



-Pretty simple – a lot of number crunching

-Used to take days, now can do in minutes.

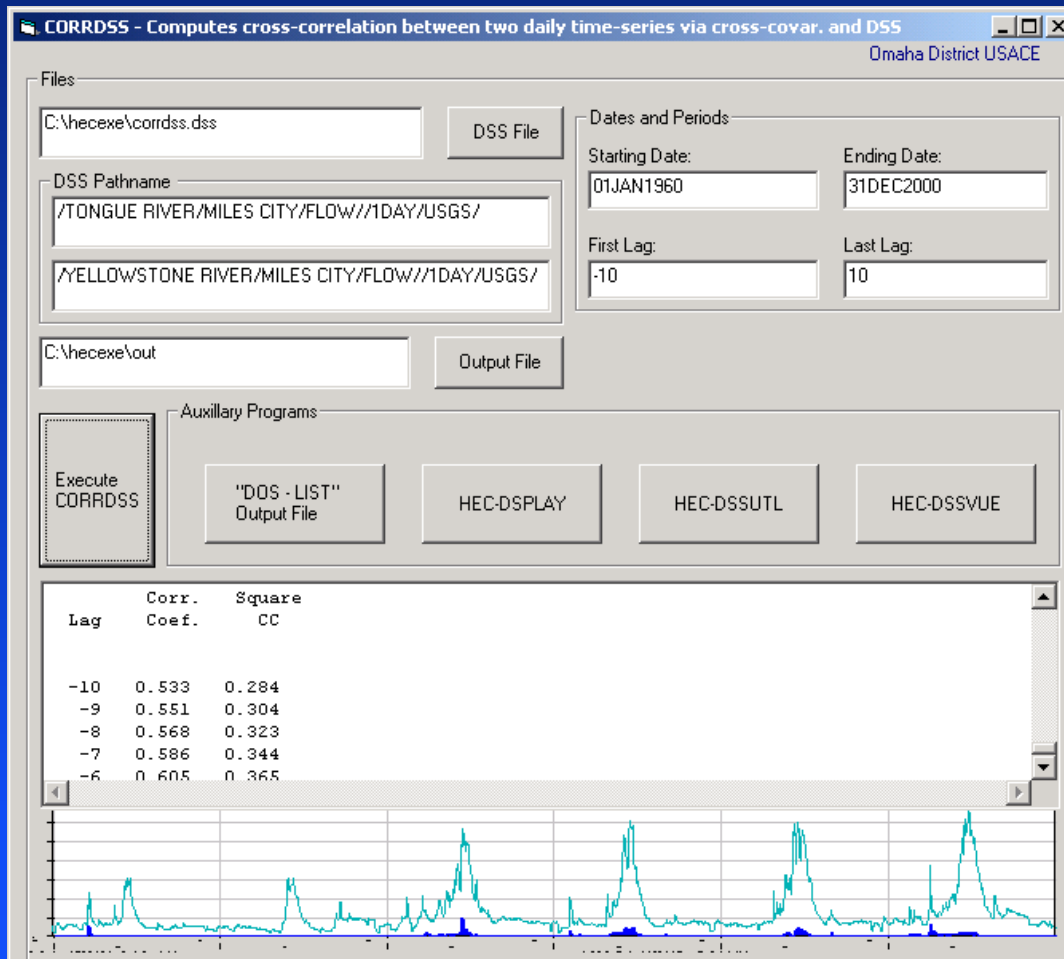




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CORRDSS



-Time-Series cross-correlation using the cross covariance

$$r_k^{ij} = \frac{C_k^{ij}}{(C_o^{ii} C_o^{jj})^{1/2}}$$

$$C_k^{ij} = \left(\frac{1}{N}\right) \sum_{i=1}^{N-k} (y_{t+k}^i - y_{mean}^i)(y_t^j - y_{mean}^j)$$

-Tells prob that 2 rivers will flood concur

-Number btwn 0 and 1 indicating coincidence

-Confluences or interior drainage analyses

-Example:

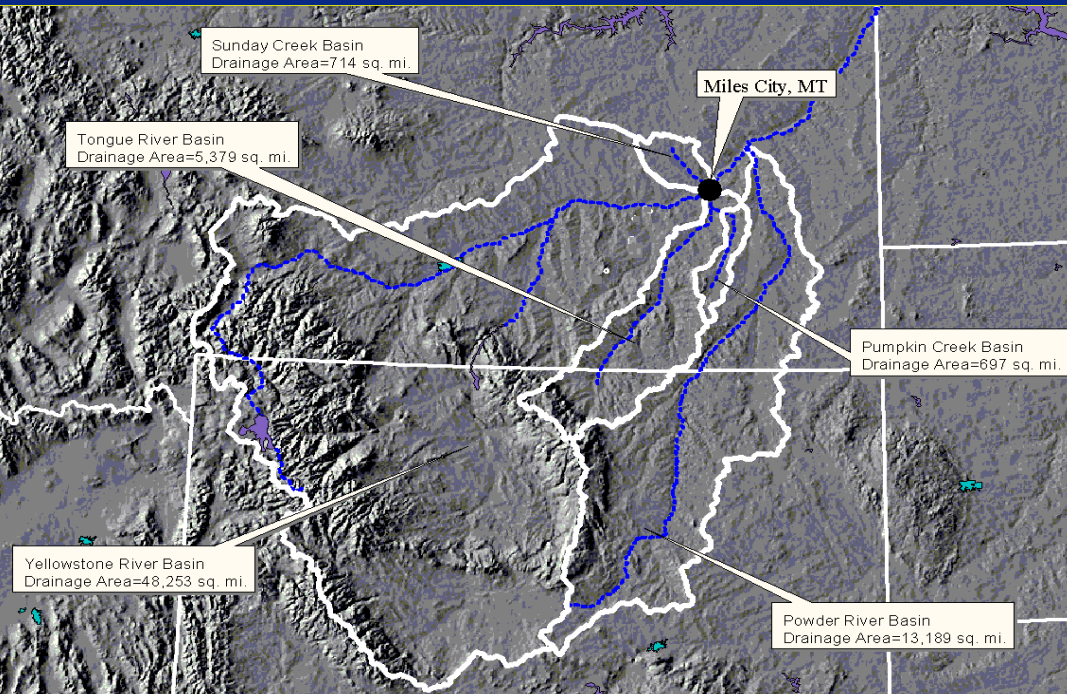




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CORRDSS Example



*Cross-Correlation Coefficients
for Various Creeks and Rivers*

	<i>Yellow stone River</i>	<i>Powder River</i>	<i>Tongue River</i>	<i>Sunday Creek</i>	<i>Pumpkin Creek</i>
Yellowstone	1.000	.486	.675	.213	.172
Powder	.486	1.000	.741	.470	.566
Tongue	.675	.741	1.000	.363	.408
Sunday	.213	.470	.363	1.000	.837
Pumpkin	.172	.566	.408	.837	1.000

- Hydrologically Similar Basins have higher CC
- Quantifies the relationship
- Analysis takes a few hours.

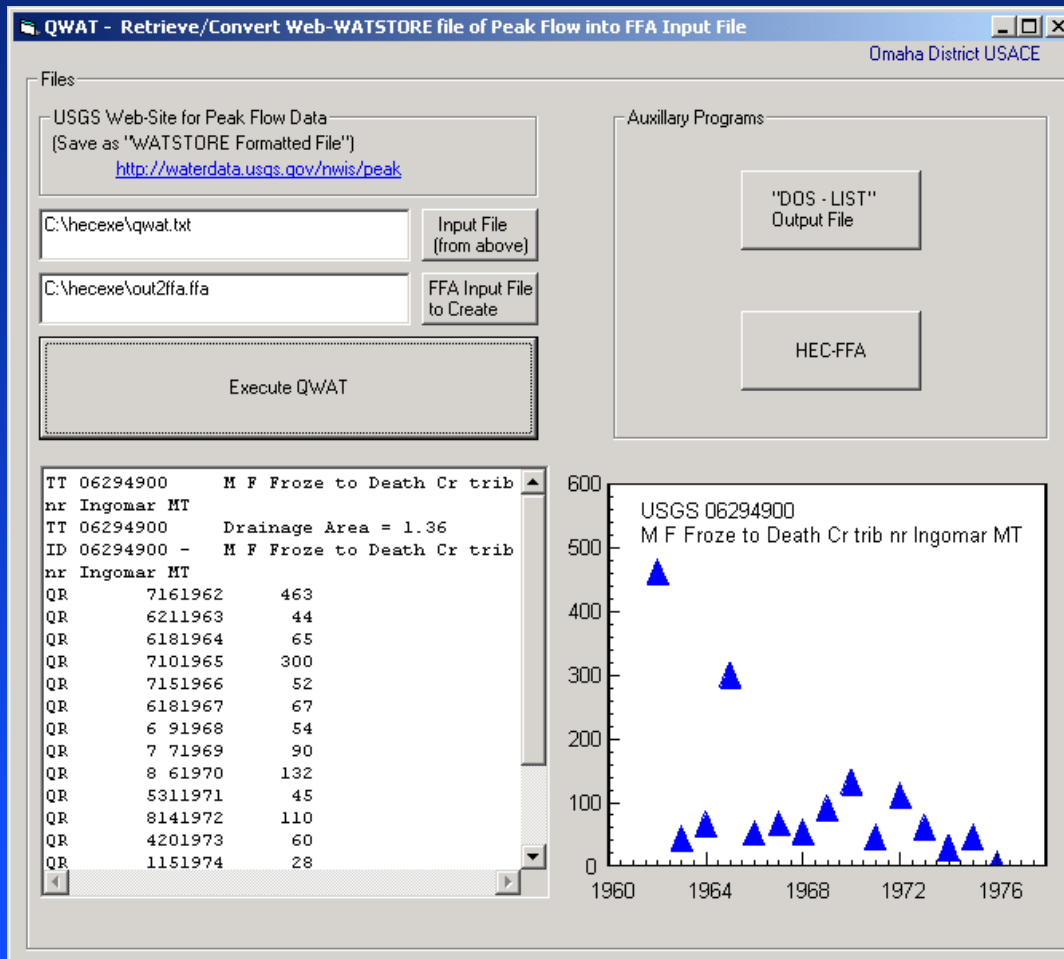




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QWAT



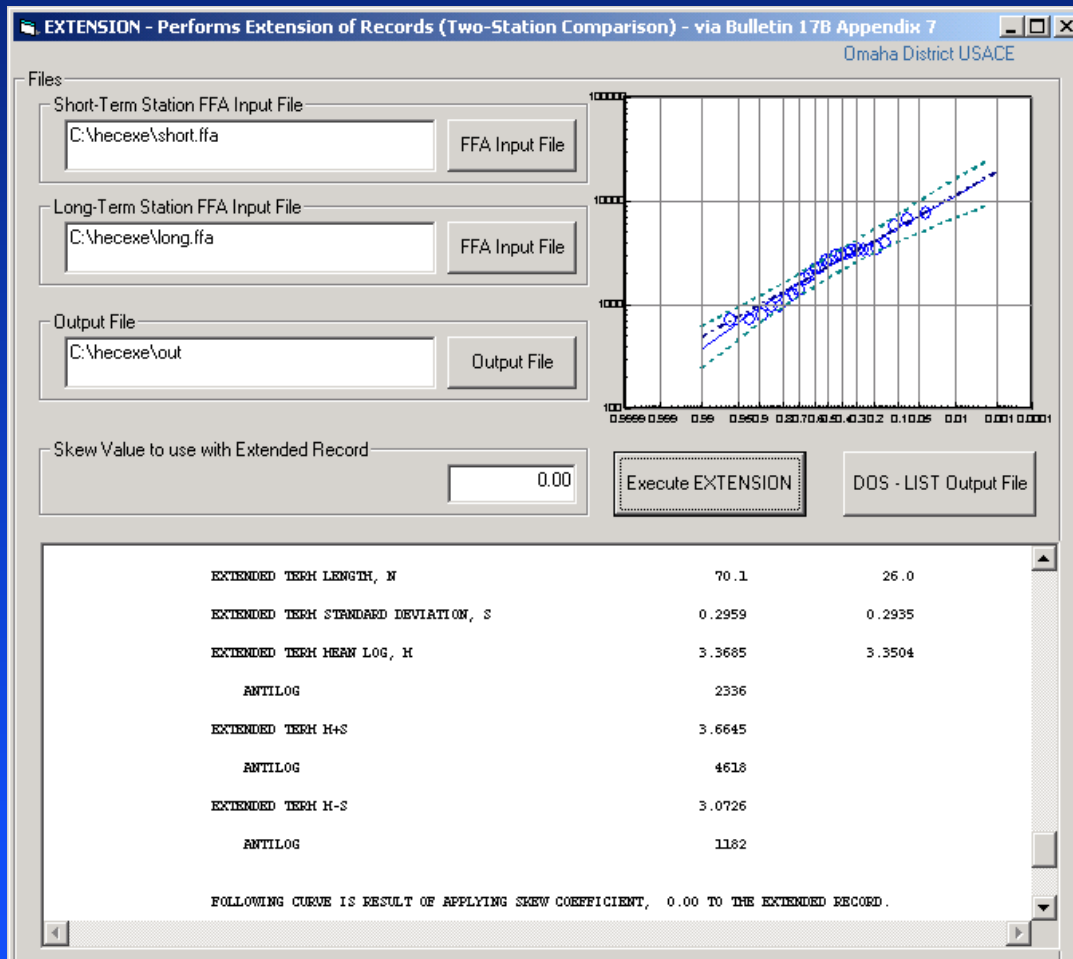
- Retrieves/Converts USGS *Peak* Flow Data
- Links to USGS Peak Flow Site using default browser
- Once find gage – download data (WATSTORE Format)
- QWAT converts to FFA Input File (QR Cards).





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OTHA – Omaha Tools for Hydrologic Analysis EXTENSION



- Extension of Records or Two-Station Comparison – Bulletin 17B – Appendix 7

- Adjusts mean log Q and stand deviation of short-term station based on long-term station

- Can use inputted skew value for freq-curve (technically this method is for zero skews)

-Example:





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EXTENSION (Example)

Statistical Properties	Short-Term Station	Long-Term Station	Extended Short-Term Station
Mean log discharge	3.3504	3.4907	3.3685
Standard deviation	0.2935	0.1904	0.2959
Years of record	29	92	70 (Equivalent)

- Modifies Statistical Parameters

- Performs Freq-Factor Equation.

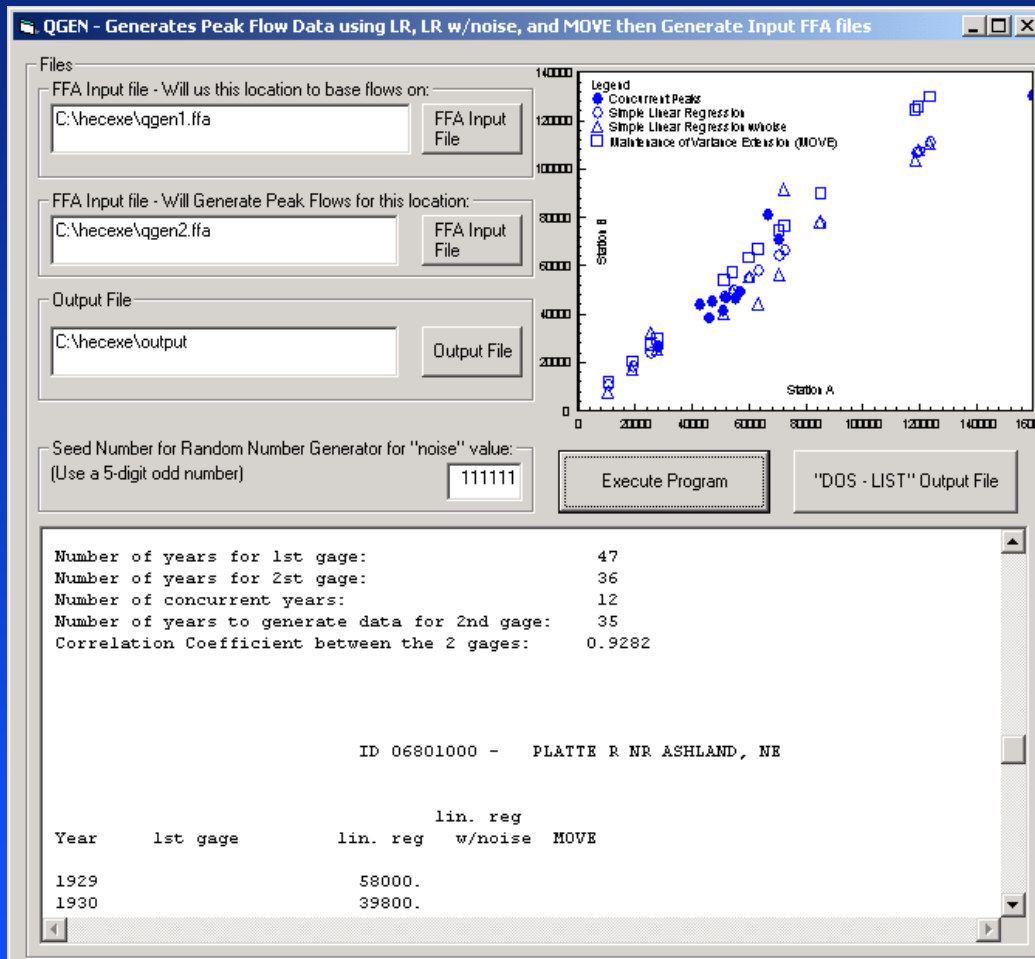




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QGEN



- Synthetic generation of individual peak flows
- Simple Linear Regression with nearby gage
- Linear Regression with "noise" (normally dist.)
- Maintenance of Variance Extension (MOVE)
- Writes-out original data combined with synthetic data to three FFA input files:
- Outlr.ffa Outlrwn.ffa Outmove.ffa

- Example:

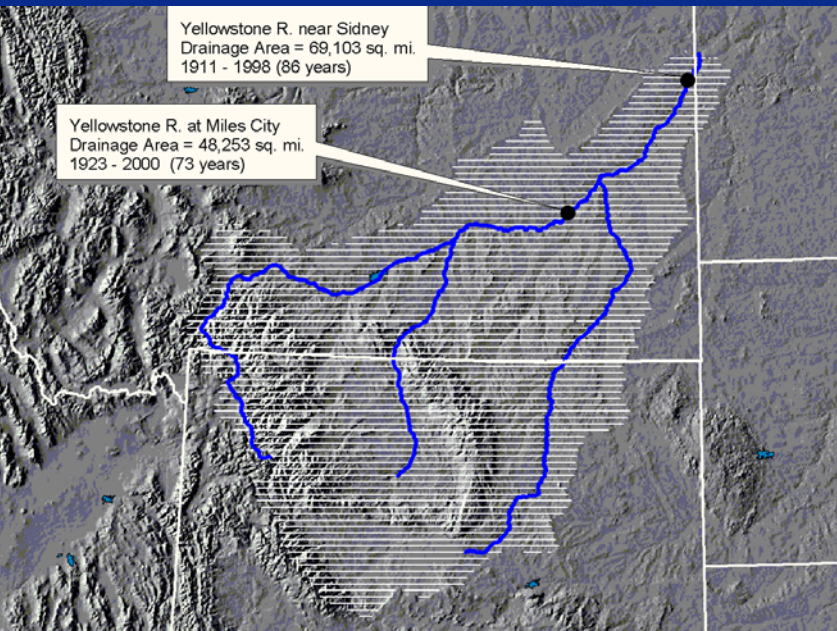




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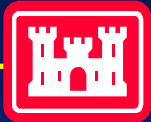
QGEN (Example)



Yellowstone River Application for Linear Regression, Linear Regression with noise, and MOVE

	<i>Yellowstone River</i>
Number of Years for Long-Term Gage (Sidney)	86
Number of Years for Short-Term Gage (Miles City)	73
Number of Concurrent Years between Gages	69
Number of Years to Generate Data	17
Correlation Coefficient	.89

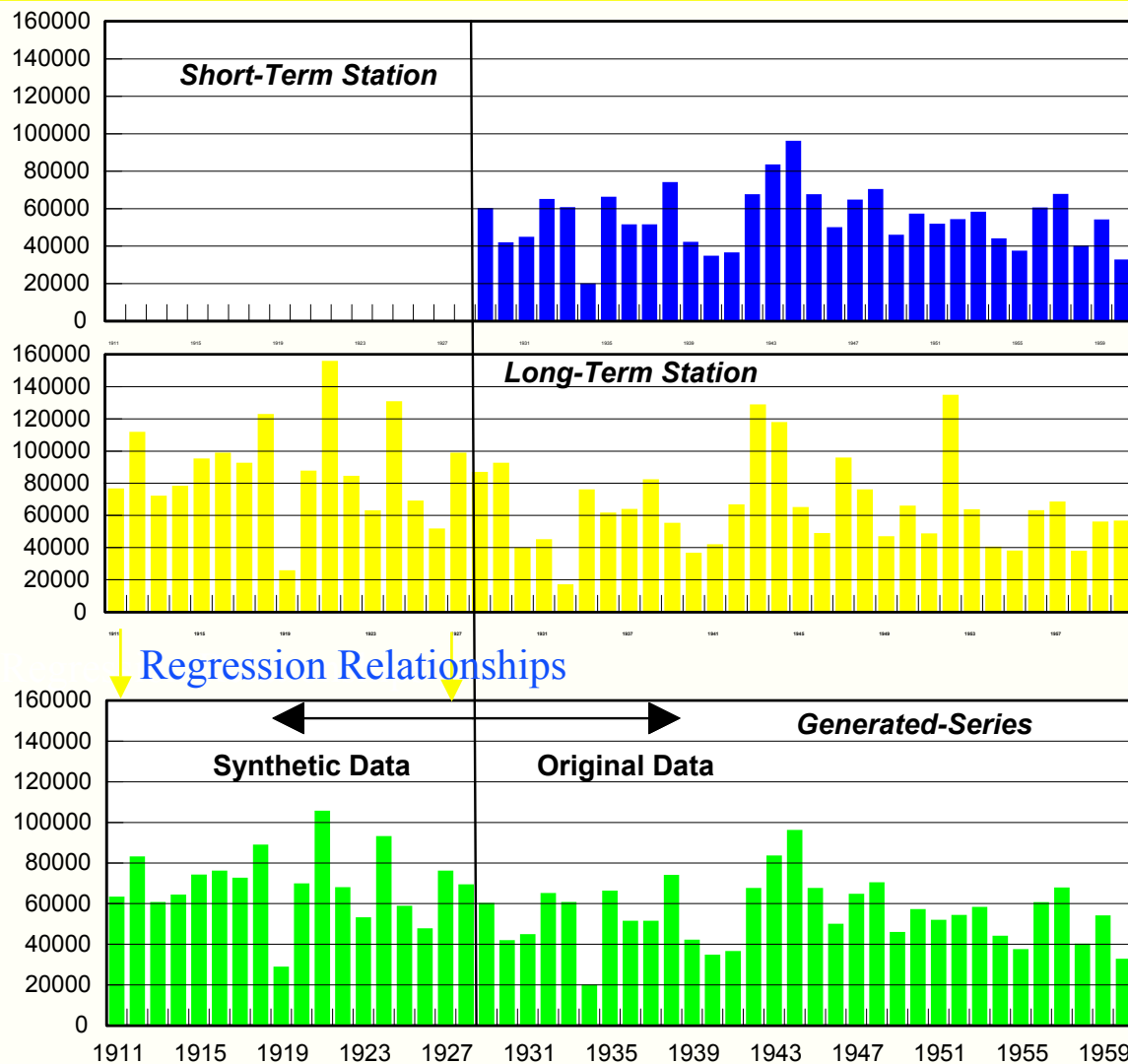




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QGEN (Example)



- Setups 3 FFA Input Files
- Run FFA.



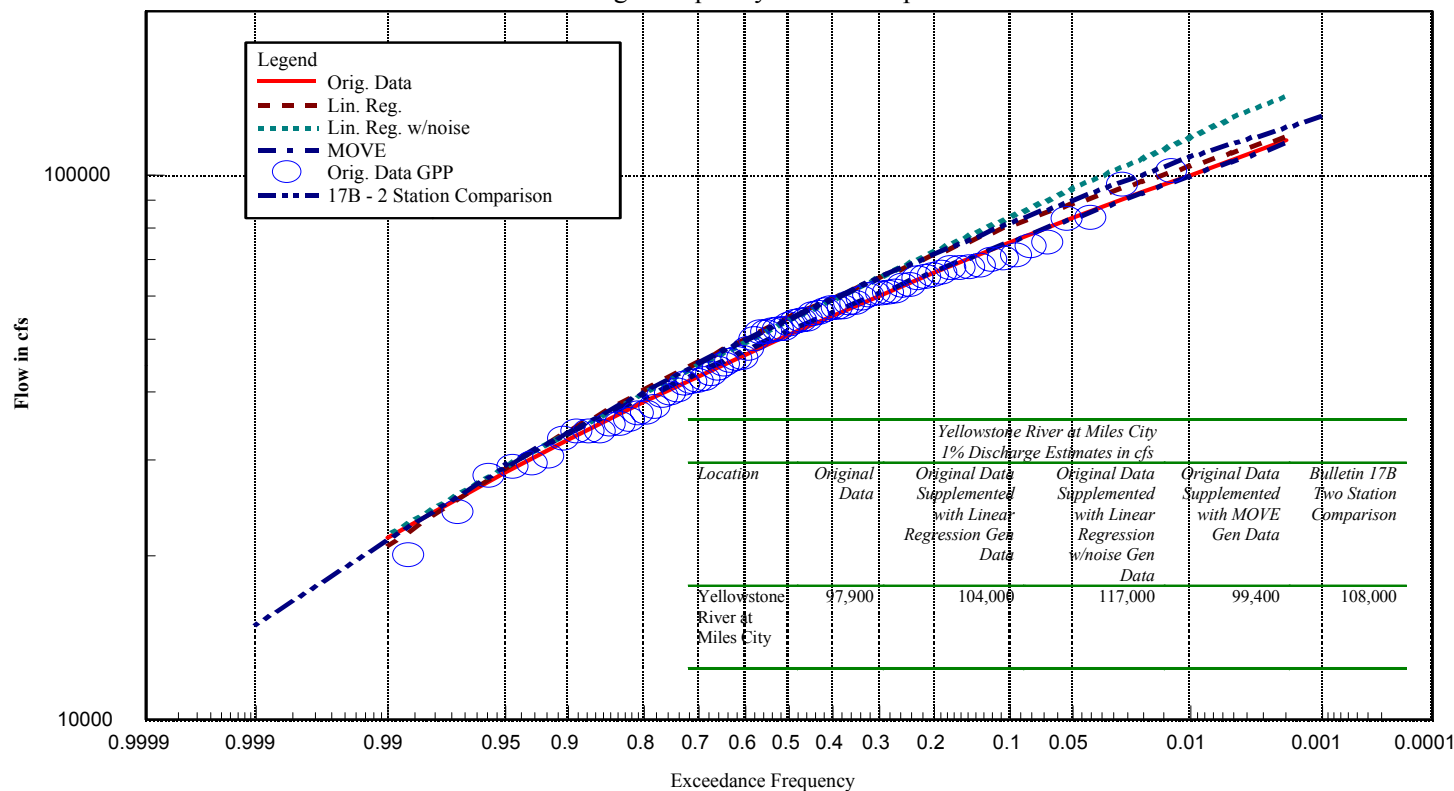


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QGEN (Example)

Yellowstone River at Miles City
Discharge-Frequency Relationships

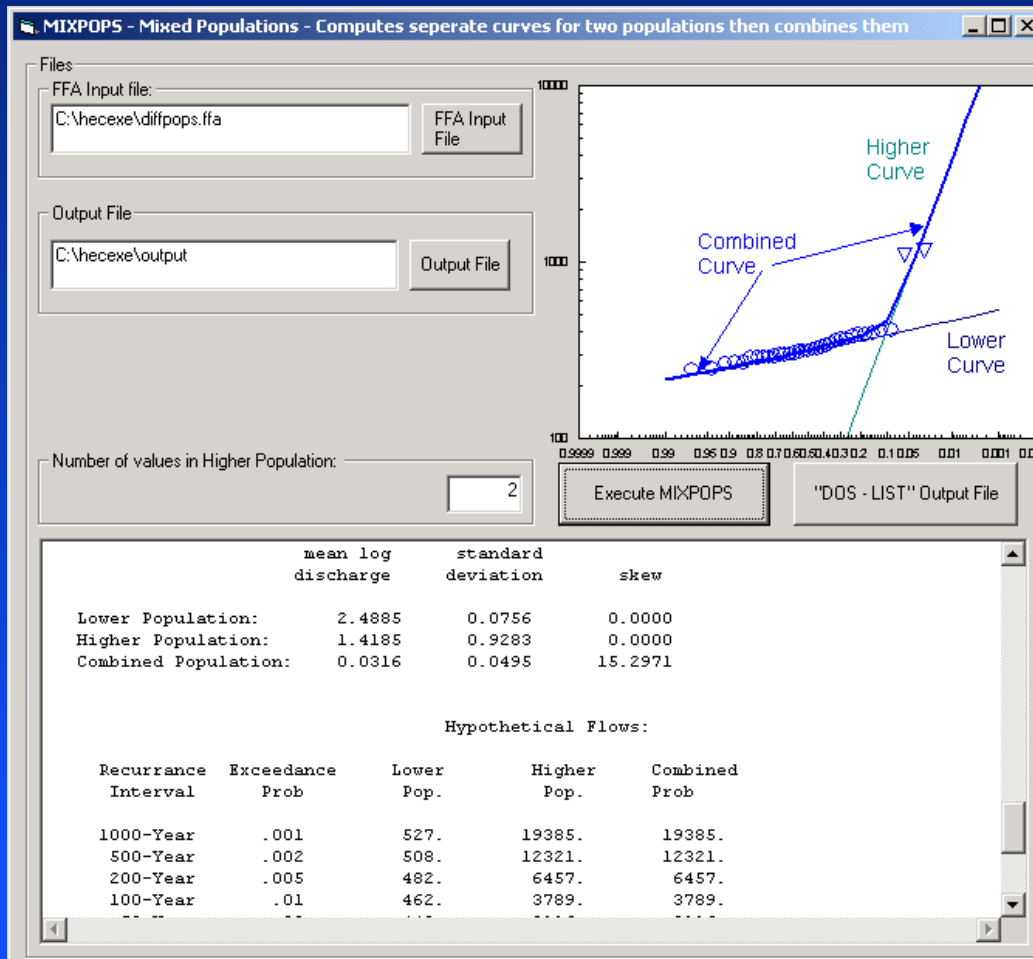




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MIXPOPS



-Freq. Analysis for a gage that has 2 physically-differentiable populations – hurricane events, snowmelt runoff, etc.

-Computes separate flow-frequency curves by converting gpp to linear distances – best-fit line

-Combines two curves using the Total Probability Theorem:

$$P_{\text{combined}} = P_A + P_B - P_A P_B$$

-Example:

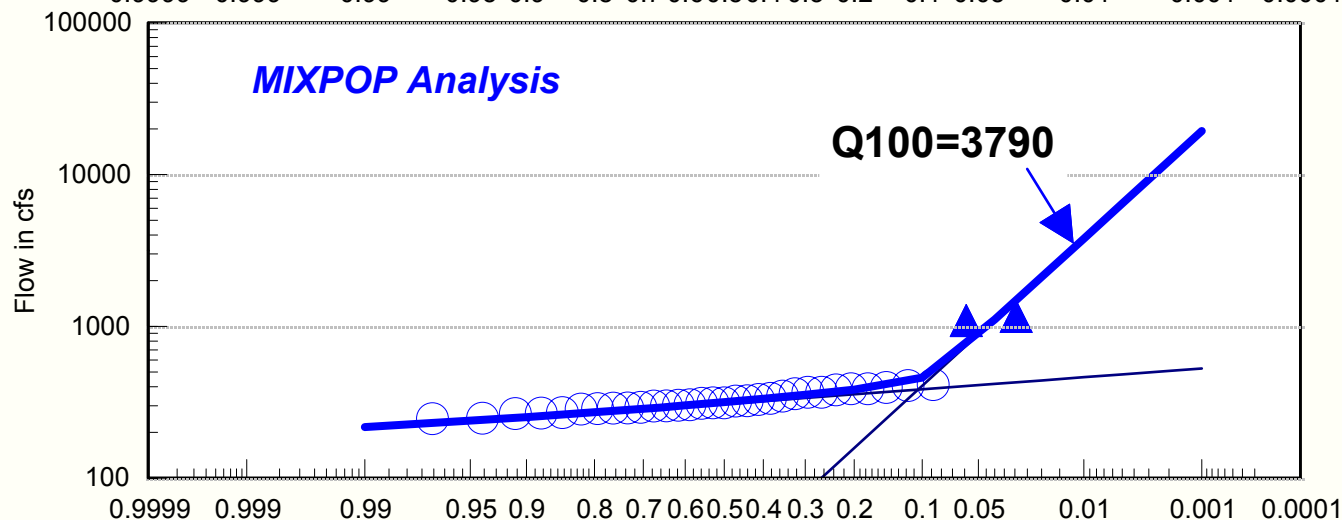
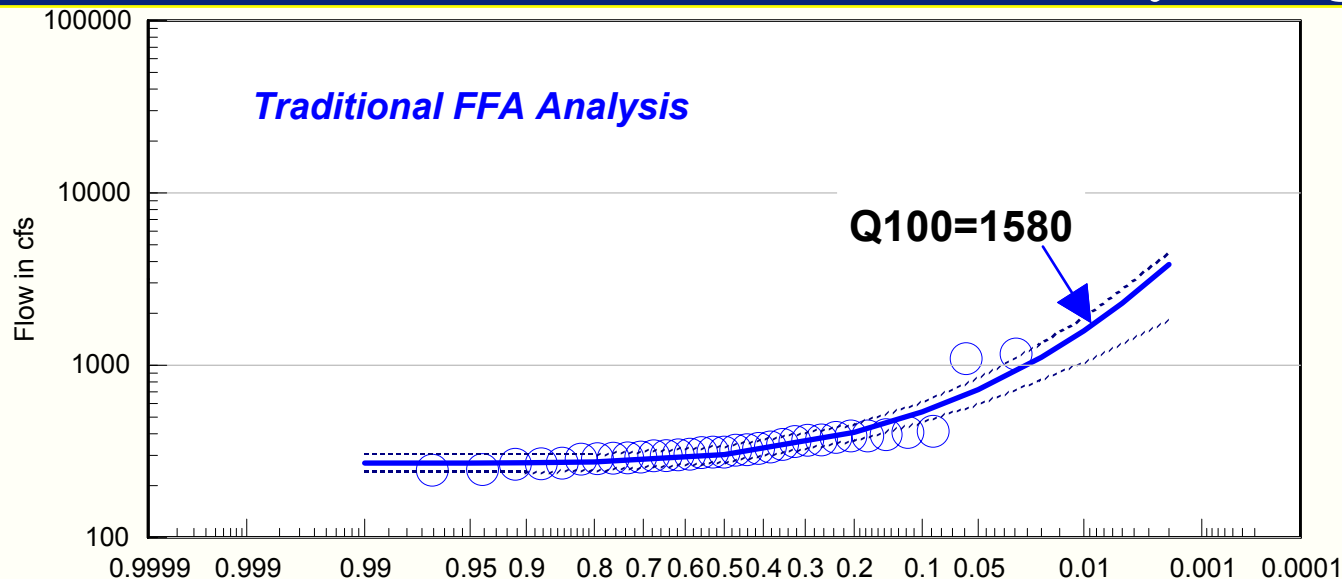




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MIXPOPS (Example)



-Provides for more
accurate flow-estimates.

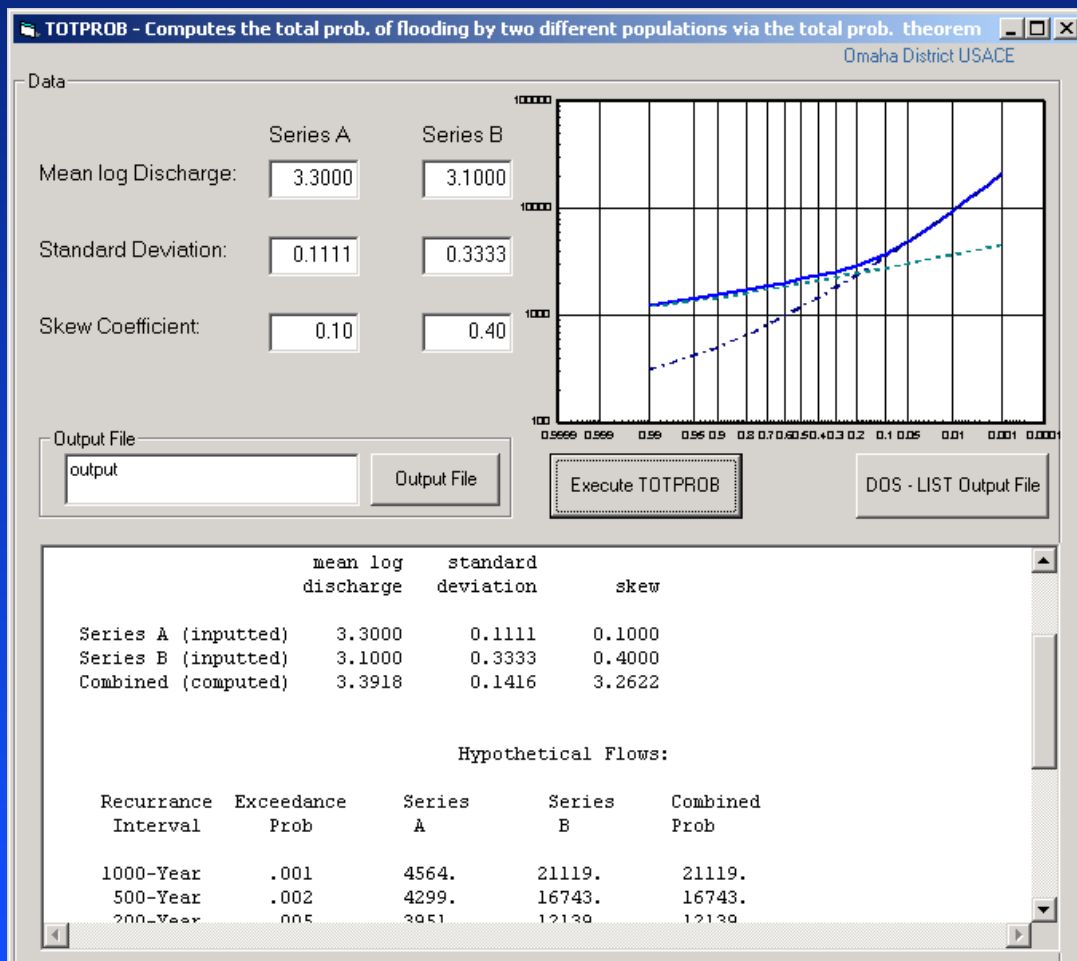




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TOTPROB



-Given statistical parameters - computes LP III distribution for two populations

-Combines two curves using the Total Probability Theorem:

$$P_{\text{combined}} = P_A + P_B - P_A P_B$$

-Regional Analysis.





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PRECFAQ

PRECFAQ - Precipitation Frequency Analysis Using GEV1 Probability Distribution Omaha District USACE

Files: C:\hecexe\precfaq.dss [DSS File]

DSS Pathname for Hourly Data: /SANDHILLS/BASSETT/PRECIP//1HOUR/NE/

C:\hecexe\out [Output File]

Auxiliary Programs: Execute PRECFAQ, "DOS - LIST" Output File, HEC-DSPRAY

Dates, Periods, and Hours for Analysis:

Starting Year: 1950 Ending Year: 1990

Starting Period: 01JAN Ending Period: 31DEC

Hours for Frequency Analysis:

1 2 3 4 5 6 12 24 48 72 96 120

Graph showing frequency analysis results for 120-Hour, 24-Hour, 6-Hour, and 1-Hour durations.

Output File: /SANDHILLS/BASSETT/PRECIP//1HOUR/NE/

* MAXVALUE	WHAT	ZONE	BEG	ZONE	END	FOUND	HR	PCTGOOD	PATHA	PATHF
1.81	1-HRMAX	01JAN1950	31DEC1950	11AUG1950	03	98.20	/SANDHILLS/NE			
1.15	1-HRMAX	01JAN1951	31DEC1951	20AUG1951	01	97.83	/SANDHILLS/NE			
1.25	1-HRMAX	01JAN1952	31DEC1952	02AUG1952	23	99.08	/SANDHILLS/NE			
0.55	1-HRMAX	01JAN1953	31DEC1953	22JUL1953	18	97.98	/SANDHILLS/NE			
0.96	1-HRMAX	01JAN1954	31DEC1954	18JUN1954	03	99.76	/SANDHILLS/NE			
0.74	1-HRMAX	01JAN1955	31DEC1955	20SEP1955	08	99.54	/SANDHILLS/NE			
0.83	1-HRMAX	01JAN1956	31DEC1956	04JUN1956	07	99.60	/SANDHILLS/NE			
0.76	1-HRMAX	01JAN1957	31DEC1957	27JUL1957	01	98.73	/SANDHILLS/NE			
2.55	1-HRMAX	01JAN1958	31DEC1958	24JUL1958	02	99.42	/SANDHILLS/NE			

-Precipitation-frequency analysis of hourly data using the GEV-1 distribution and DSS

-Can input up to 12 different durations, (1-hour, 2-hour, 6-hour, 12-hour, etc.)

-Sorts out max “n-hour” value for each year

-Computes graphical frequency analysis and analytical solution for the GEV-1 distribution

-Monthly, seasonal, or annual basis

-Example:

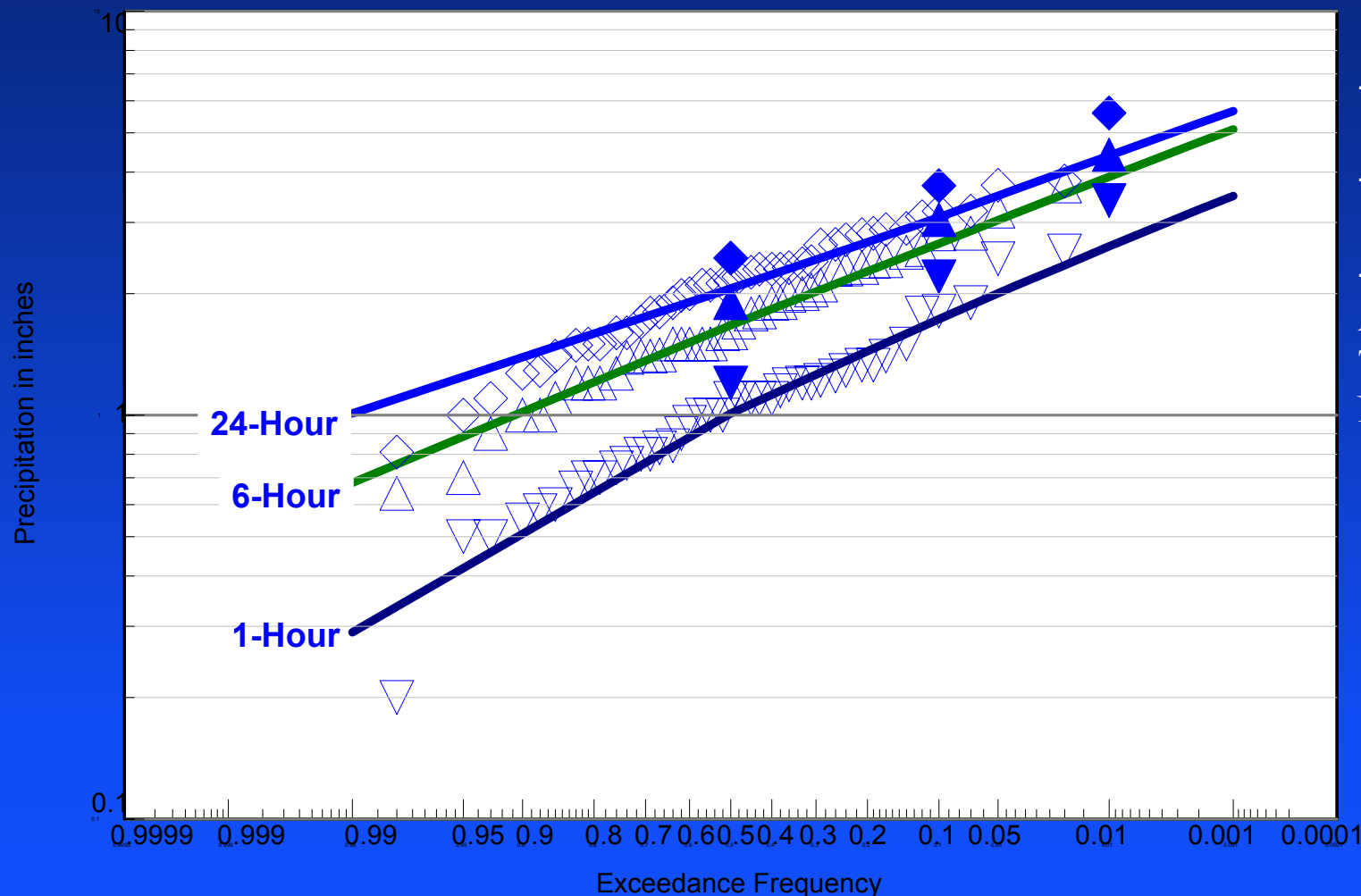




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PREC_FREQ



- Graphical Freq
- Analytical Freq
- Comparison/
Alternative to
TP 40 or
NOAA Atlas.





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RISK

RISK - Computes Total Risk of "Failure" during Project Life using the Binomial Distribution
Omaha District USACE

Data

Total Risk of **at Least one** Failure over Project Life:

Exceedance Probability in any given year: (Ex: .50, .10, .02, .01, etc.)

(Number of failures=at least one)

Project Life in Years:

Execute RISK1 $P = 1 - (1 - \frac{1}{T})^n$

Output File:

Probability of failure in any given year: 0.0100

Recurrence Interval (in years) for failure: 100.

Number of failures: (at least one)

Project Life in years: 10

Total Risk of Failure during Project Life:

Total Risk of **Exactly Given Number** of Failure(s) over Project Life:

Exceedance Probability in any given year: (Ex: .50, .10, .02, .01, etc.)

Exact Number of failures:

Project Life in Years:

Execute RISK2 $P = \frac{n!}{(n-k)!k!} P^k (1-P)^{n-k}$

Output File:

Probability of failure in any given year: 0.0100

Recurrence Interval (in years) for failure: 100.

Number of failures: 2.

Project Life in years: 10

Total Risk of Failure(s) during Project Life:

-Computes total risk of “failure” over project life using Binomial Distribution

-Computes “at least one” failure or exact given number of failures

-Example: Risk of having a 100-year flood in a ten year period is 9.6%

-Example: Risk of having 3 100-year floods in a ten year period is 0.4%.

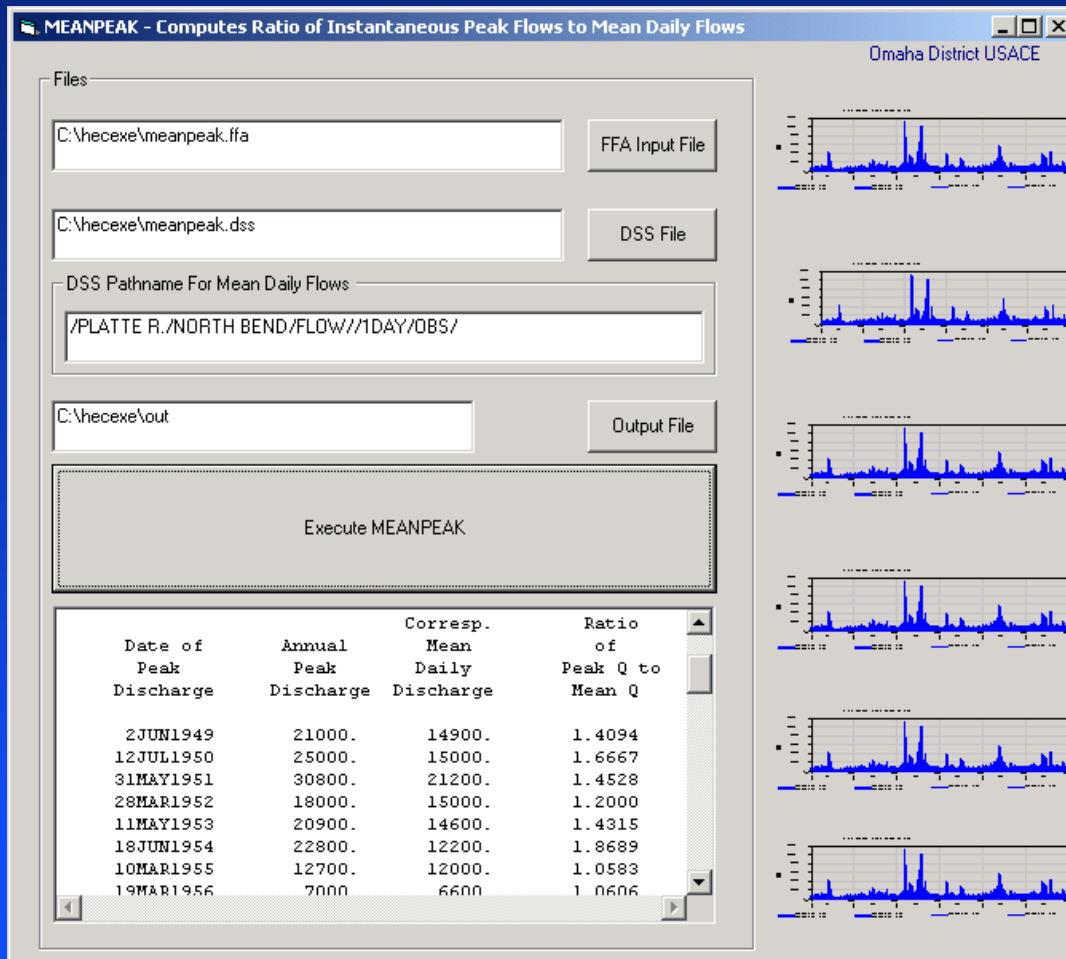




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MEANPEAK



-Computes ratio of instantaneous peak flows to mean daily flows for each year

-From FFA file, determine which day peak flow occurred, then goes to DSS file to see what the corresponding mean daily flow was for that day – determines ratio

-Determines the mean annual ratio and the regression relationship between peak flow and ratio

-Example:





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MEANPEAK (Example)

/PLATTE R./NORTH BEND/FLOW//1DAY/OBS/

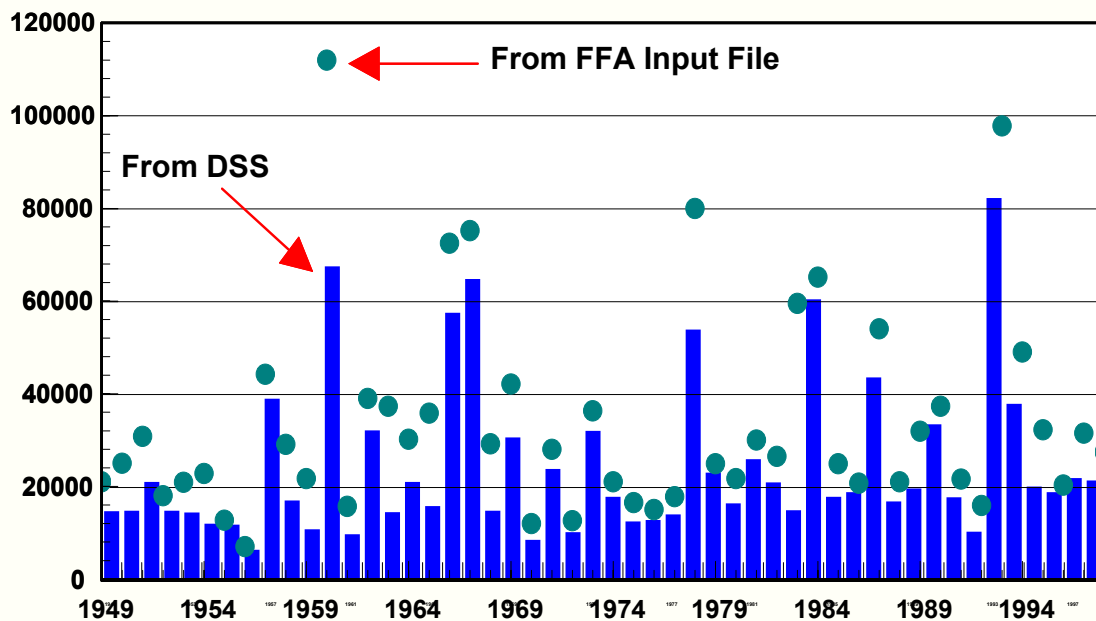
Date of Peak	Annual Peak Discharge	Corresp. Mean Daily Discharge	Ratio of Peak Q Mean Q
2JUN1949	21000.	14900.	1.4094
12JUL1950	25000.	15000.	1.6667
31MAY1951	30800.	21200.	1.4528
28MAR1952	18000.	15000.	1.2000
11MAY1953	20900.	14600.	1.4315
18JUN1954	22800.	12200.	1.8689
10MAR1955	12700.	12000.	1.0583
19MAR1956	7000.	6600.	1.0606
17JUN1957	44200.	39100.	1.1304
.	.	.	.
.	.	.	.
24MAR1987	54000.	43700.	1.2357
27FEB1988	21000.	17000.	1.2353
13MAR1989	31900.	19800.	1.6111
17JUN1990	37300.	33600.	1.1101
3JUN1991	21600.	17900.	1.2067
6AUG1992	15900.	10500.	1.5143
10MAR1993	97800.	82300.	1.1883
5MAR1994	49000.	38000.	1.2895
28MAY1995	32200.	20200.	1.5941
2JUN1996	20300.	19000.	1.0684
21FEB1997	31500.	22000.	1.4318
19JUN1998	27400.	21500.	1.2744

LINEAR REGRESSION ANALYSIS:

Average Mean Daily Flow= 24824.
Average Ratio of Qp to Qm= 1.43171

Y-Intercept= 1.4811220169
Slope= -0.0000031839

$Q_p = [1.4811220169 + -0.0000031839(Q_m)] (Q_m)$

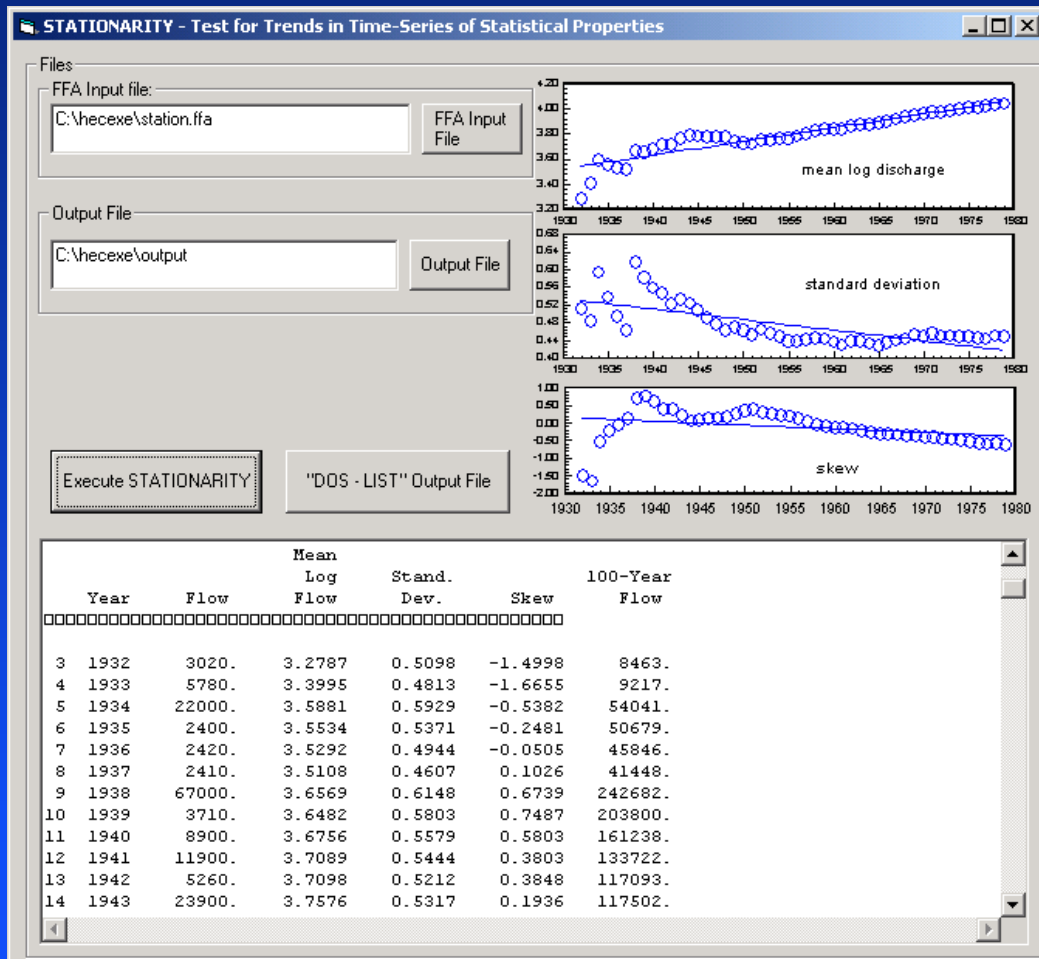




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OTHA – Omaha Tools for Hydrologic Analysis

STATIONARITY



- Tests for stationarity in statistical parameters
- Essentially FFA in a loop – time-series of statistical parameters
- Performs trend-analysis on stat. parameters
- Performs statistical significance using t-test (checking if slope of line is significant)

- Example:



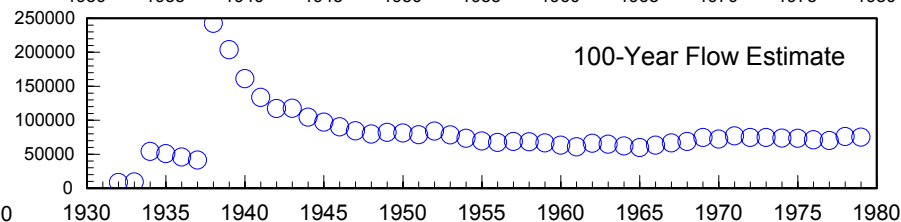
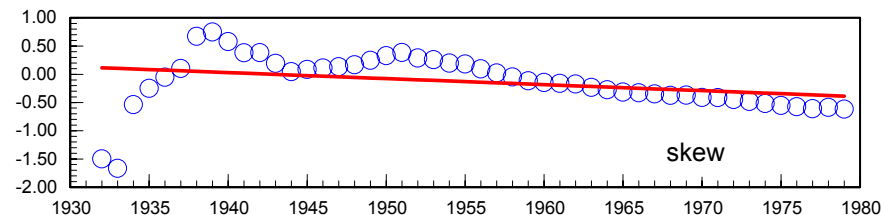
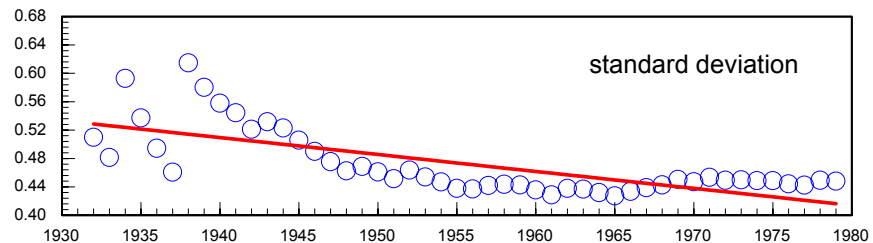
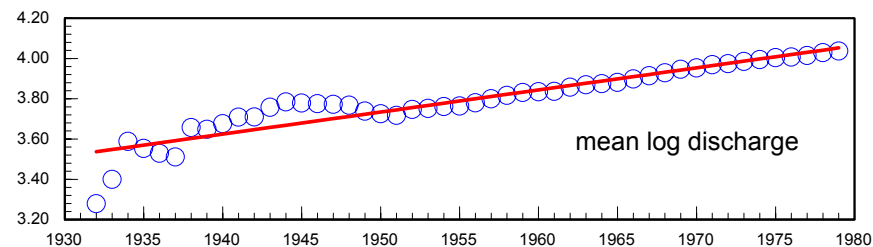
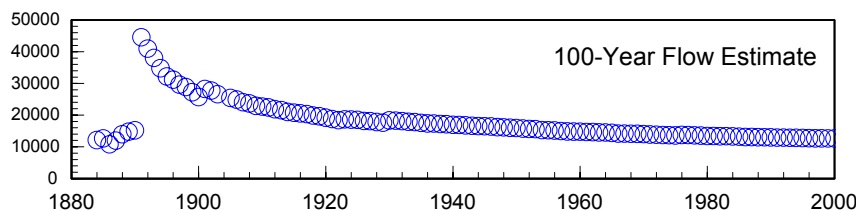
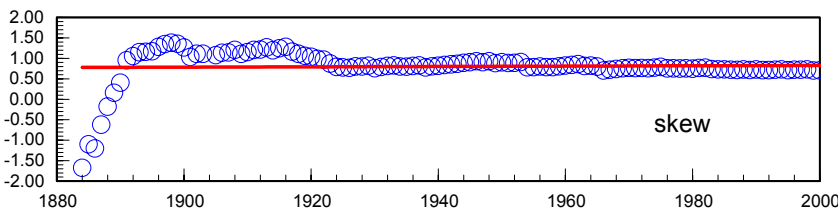
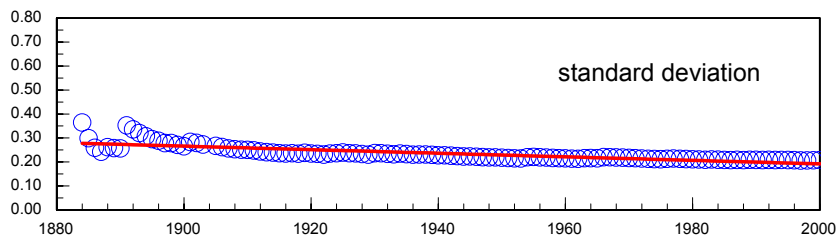
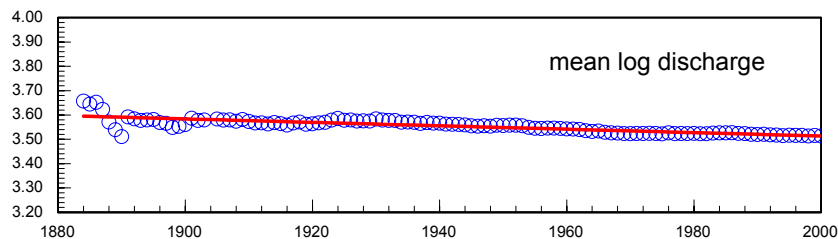


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- Mountain Watershed

STATIONARITY (Example) - Urbanizing Watershed

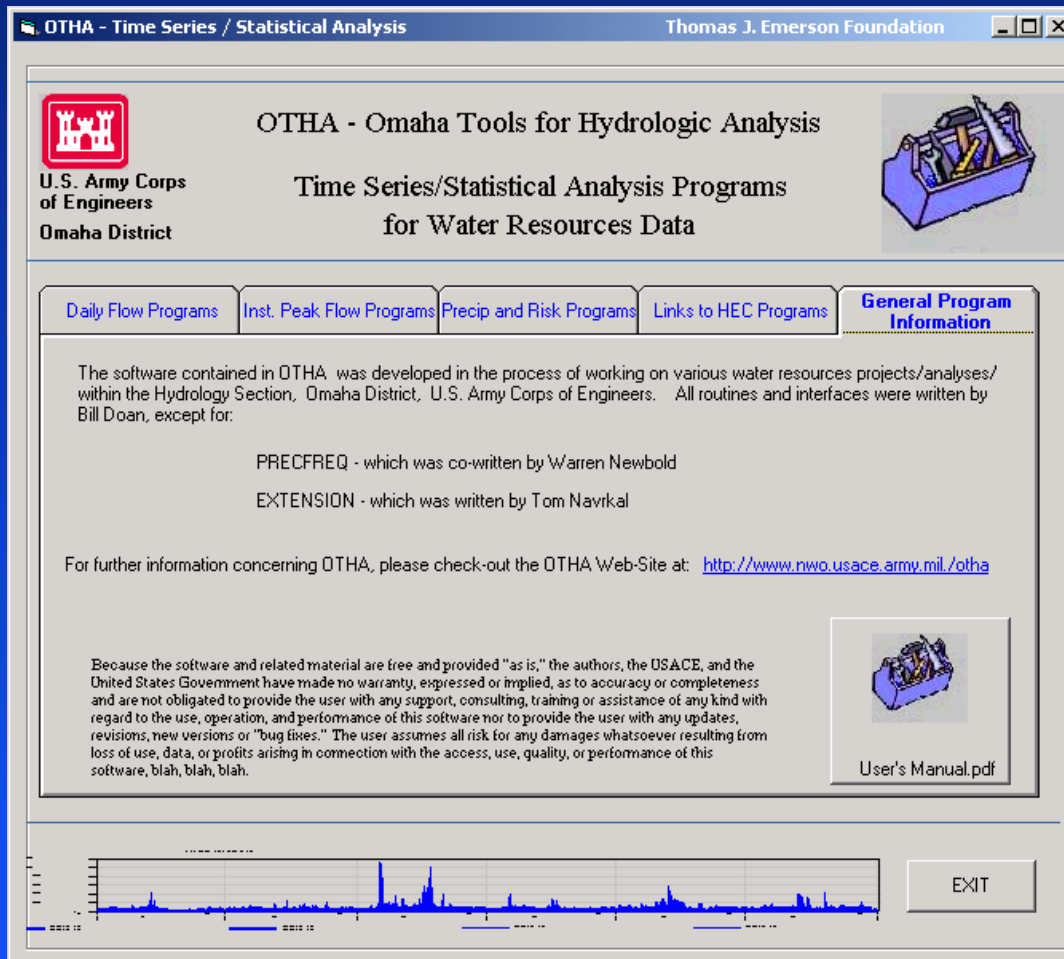




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Conclusion



- Built-in Users Manual and link to Web-Site

- All routines have been used/tested in the Omaha District on a variety of projects

-All routines have built-in example files which are also the default values

-Written by/for Omaha District – available to whomever could use it

-For further information or downloads:

- www.nwo.usace.army.mil/otha

Questions?

